Fermilab

Particle Physics Division

Mechanical Department Engineering Note

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Project: CMS Upgrade Cooling System Test Design

Title: CO2 Hazard and ODH

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Abstract Summary:

CO2 gas has unique hazards that can occur before an ODH condition occurs. This note summarizes the hazard and provides a means of calculating a fatality factor for use in CO2 hazard assessment.

CO2 TOXICITY

CO2 is a natural byproduct of life and a natural component of fresh air. Ambient fresh air contains about 350 ppm CO2.

Typical indoor air can contain higher concentrations of CO2, on the order of 350 ppm to 1000 ppm under conditions of good air exchange.

At higher CO2 concentrations one can experience headaches, dizziness, shortness of breath and irregular heart rate.

For this reason CO2 is listed as a toxic contaminant by The National Institute for Occupational Safety and Health (NIOSH) which is part of the Center for Disease Control (CDC).

NIOSH exposure limit are:

- 5000 ppm/0.5% - TWA (Time Weighted Average, 10 hr)
- 30,000 ppm/3.0% - STEL (Short Term Exposure Limit)
- 40,000 ppm/4.0% - IDLH (Immediately Dangerous to Life and Health)

The NIOSH IDLH value is based on a 30 minute exposure. The NIOSH basis data reports CO2 at 100,000 ppm/10%, produces unconsciousness in a matter of minutes.

CO2 HAZARD AND ODH

CO2 hazard can be assessed in a similar fashion to oxygen deficiency hazard (ODH), detailed in FESHM 5064.

The CO2 fatality factor is zero for CO2 concentrations less than 5000 ppm/0.5%.

FESHM 5064 sets the ODH fatality equal to one when oxygen drops to a concentration that produces unconsciousness after about a minute. The comparable point for CO2 hazard is 100,000 ppm/10% CO2 and making the CO2 fatality factor equal to one for CO2 concentrations at or above this level.

For CO2 displacement gas, the relationship between oxygen and CO2 concentration is:

$$\%O_2 = 21\% \cdot \frac{(100\%AIR - \%CO_2)}{(100\%)}$$

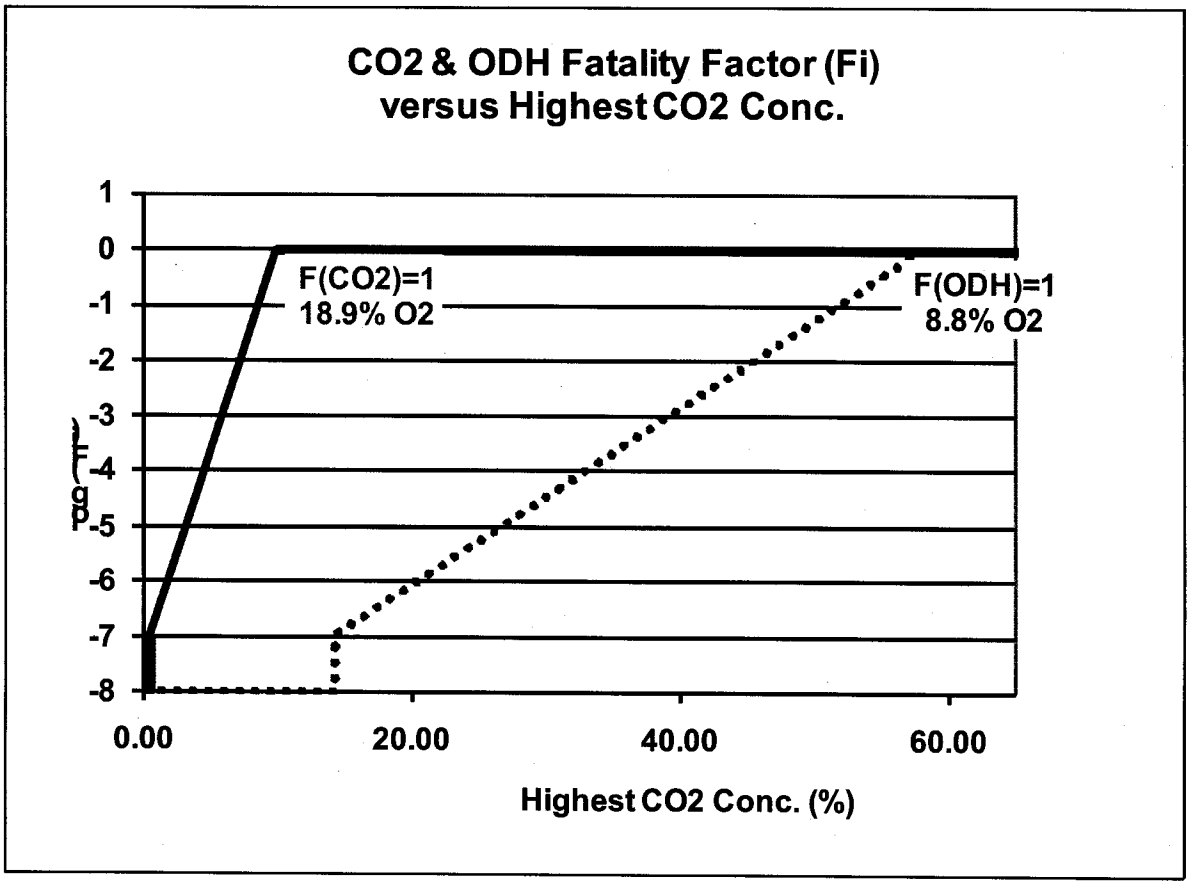
Rearranged to solve directly for CO2 concentration:

$$\%CO_2 = 100\%AIR - \frac{(\%O_2)}{(21\%)} \cdot 100\%$$

At 18% oxygen the CO2 would be 14.3% or 143,000 ppm CO2. This is in excess of the CO2 concentration defined as having a fatality factor of 1, but the ODH fatality factor would be zero.

For cases where the displacing gas is CO2, the CO2 hazards needs to be assessed. When CO2 hazards are present the ODH assessment is superseded by the CO2 hazard and a separate ODH assessment has no meaning within this context.

This can be seen on a graph of the CO2 fatality factor compared to the ODH fatality factor.



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